

1. A method of manufacturing a semiconductor device, the method comprising:

forming a first dielectric layer on a substrate;

forming a first patterned conductive layer having gaps on the first dielectric layer, the first patterned conductive layer comprising a first conductive feature having an upper surface and side surfaces;

depositing a dielectric gap fill layer to fill the gaps;

depositing a second dielectric layer on the first patterned conductive layer and on the gap fill layer;

forming a photoresist mask on the second dielectric layer;

forming a through-hole in the second dielectric layer exposing the upper surface of the first conductive feature; and

removing the photoresist mask and cleaning the through-hole with a plasma containing carbon tetrafluoride (CF<sub>4</sub>) and water vapor (H<sub>2</sub>O), wherein the as-deposited gap fill layer and/or the second dielectric layer have a dielectric constant no greater than about 3.

- 2. The method according to claim 1, wherein the gap fill layer and/or the second dielectric layer have an as-deposited dielectric constant of about 1.8 to about 3.
- 30 3. The method according to claim 1, wherein the gap fill layer and/or the second dielectric layer comprise hydrogen silsesquioxane (HSQ).
- 4. The method according to claim 1, comprising removing the photored ist mask and cleaning the throughhole such that the dielectric constant of the gap fill

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layer and/or second dielectric layer does not increase more than about 15%.

- 5. The method according to claim 1, comprising removing the photoresist mask and cleaning the throughhole such that the dielectric constant of the gap fill layer and/or second dielectric layer does not increase more than about 10%.
- 10 6. The method according to claim 3, comprising removing the photoresist mask and cleaning the throughhole such that the number of Si-H bonds in the asdeposited HSQ gap fill layer and/or second dielectric layer is not reduced below about 60% to about 80%.
  - 7. The method according to claim 6, comprising removing the photoresist mask and cleaning the throughhole such that the number of Si-H bonds in the HSQ gap fill layer or second dielectric layer is not reduced below about 70% of the Si-H bonds in the as-deposited HSQ gap fill or second dielectric layer.
  - 8. The method according to claim 7, wherein the HSQ gap fill layer and/or second dielectric layer have a dielectric constant of about 3.1 to about 3.3 after removing the photoresist mask and cleaning the throughhole.
- 9. The method according to claim 1, comprising removing the photoresist mask at a rate of about 10 to about 20KÅ/min.
- 10. The method according to claim 9, comprising removing the photoresist mask and cleaning the through35 hole at a:

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and

temperature of about 190°C to about 290°C;
RF power of about 800w to about 1,200W;
pressure of about 960 to about 1,440 mTorr;
an H<sub>2</sub>O flow rate of about 240 to about 360 sccm;

a CF<sub>4</sub> flow rate of about 30 to about 60 sccm.

- 11. The method according to claim 10, comprising removing the photoresist mask for about 20 to about 60 seconds.
  - 12. The method according to claim 1, comprising forming the through-hole in the second dielectric layer exposing a portion of the upper surface and at least a portion of a side surface of the first conductive feature and penetrating into and exposing a portion of the gap fill layer.
- 13. The method according to claim 12, comprising filling the through-hole with conductive material to form a borderless via.

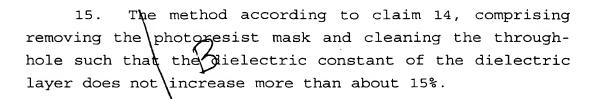
device, the method comprising:

depositing a layer of dielectric material, having an as-deposited dielectric constant no greater than about 3, over a conductive region or conductive feature;

forming a through-hole in the dielectric layer exposing the upper surface of the conductive region or conductive feature; and

removing the photoresist mask and cleaning the through-hole with a plasma containing carbon tetrafluoride  $(QF_4)$  and water vapor  $(H_2O)$ .

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16. The method according to claim 14, wherein the dielectric material comprises hydrogen silsesquioxane (HSQ).

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17. The method according to claim 16, comprising removing the photoresist mask and cleaning the throughhole such that the number of Si-H bonds in the asdeposited HSQ dielectric layer is not reduced below about 70%.

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18. The method according to claim 17, wherein the HSQ dielectric layer has a dielectric constant of about 3.1 to about 3.3 after removing the photoresist mask and cleaning the through-hole.

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19. The method according to claim 14, comprising removing the photoresist mask as a rate of about 10 to about 20KÅ/min.

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- 20. The method according to claim 19, comprising removing the photoresist mask with a water vapor plasma:
  - at a temperature of about 190°C to about 290°C;
  - at an RF power of about 800W to about 1,200W;
  - at a pressure of about 960 to about 1,440 mTorr;
- at an  $\rm H_2O$  flow rate of about 240 to about 360 sccm; and

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at a  $CF_4$  flow rate of about 30 to about 60 sccm; for about 20 to about 60 seconds.